Omnibus Scope of Work
Sampling Design and Protocol Development

Submitted by
The Natural Resources Research Institute
And
The Great Lakes Inventory & Monitoring Network

Through
The Great Lakes- Northern Forest Cooperative Ecosystems Studies Unit

Funding provided by the
US National Park Service
Great Lakes Inventory & Monitoring Network

Introduction:

The National Park Service (NPS) Great Lakes Inventory and Monitoring (I&M) Network (GLKN) has developed a prioritized list of 46 indicators, termed *Vital Signs*, for monitoring long-term ecosystem health for nine NPS units in the Great Lakes region (Route 2004). GLKN must submit a draft final monitoring plan, the *Phase 3 Report*, to their national I&M office by December 15, 2005. This draft plan must describe how GLKN intends to monitor Vital Signs across all nine parks. The plan must also include an overall sampling framework, protocols for high priority Vital Signs, brief summaries for lower priority Vital Signs, and a data management plan. This Phase 3 Report will be peer reviewed and approved by the NPS national I&M team before the Network can proceed with monitoring.

A defensible monitoring program should, at minimum, address three primary elements (Noon 2003): First, it should provide a clear statement of the importance of the monitoring program. GLKN has conducted scoping workshops at each of the nine parks (Route 2003) and has engaged managers and science partners to help determine the managerial and ecological significance of the Vital Signs (Route 2004). These efforts were designed to ensure that the purpose and goals of the program were strongly supported by managers and scientists. Noon's second assertion is a clear articulation of the logic and rationale for selecting the indicators (i.e. Vital Signs) of interest. A goal of the project described herein, is to go a step beyond the initial selection process and clearly illustrate the linkages for an initial subset of the GLKN Vital Signs. We will develop conceptual models to show clear linkages of this initial subset which will provide a diagrammatic structure to insert the remaining Vital Signs. Finally, Noon echoes the current trend in regional monitoring programs by illustrating the need for an overarching sampling design and for clear methods of measuring the selected indicators. In this project we intend to develop a sampling framework and protocols for the initial subset of five Vital Signs. This will provide a template, in which the remaining Vital Signs will be placed.

The development of detailed sampling protocols and a sampling framework requires a high degree of expertise in several disciplines that include various biota, remote sensing, statistics, and monitoring theory (Trexler and Busch 2003). Further, the implementation of a viable, long-term monitoring program will require partnering with agencies and universities around the Great Lakes region. In this project, GLKN seeks collaboration with university and agency partners who can help design protocols, conduct peer-review, ensure the statistical rigor of the program, and join in long-term partnering to achieve mutual goals.

Objectives:

1. Develop detailed sampling protocols for the following high-ranking Vital Signs:
    a. Water quality for stream systems
    b. Water quality for lake systems
    c. Land use/landscape change
    d. Terrestrial vegetation
    e. Amphibians
2. Develop a sampling framework that will facilitate the use of common or closely connected sampling sites or areas, with the intention of increasing efficiency, statistical rigor, and opportunities to provide 'weight of evidence' data to assess ecosystem change.
3. Develop the underlying architecture of a data management system that will increase the efficiency and reliability of collecting data in the field, facilitate the examination and summary of the data by end users, and maximize the ability to do synthetic, integrative analyses in the future.
4. Submit one or more scientific papers targeted for *Ecological Applications* or other highly regarded peer reviewed journals to be agreed upon by the network coordinator and authors. The publication(s) will document the management and ecological significance of key indicators, the scientific rationale behind the sampling framework that will be used by the Great Lakes Network, and if applicable, summary protocols that will be used for long-term monitoring.

Rationale for co-developing the initial five monitoring protocols:

The development of monitoring protocols for 46 Vital Signs in nine park units across four states is a daunting task. It is necessary to break this complex problem down in to an initial subset of high ranking Vital Signs for all nine parks. The five we selected are all ranked in the top 10 by members of focus workshops and park staff. Additionally, the spatial extent at which the five Vital Signs respond to environmental stress ranges from the landscape scale (land use, vegetative cover) to finer scales (water quality, amphibians). Although one of our primary objectives is to link sampling sites for increased efficiency, we anticipate that developing protocols for indices that occur at multiple scales will be difficult. Thus our selection of these five indices will allow us to address this problem at the onset. Further, by developing the terrestrial vegetation and water quality protocols first, we increase our chances of selecting a matrix of land and water-based sampling sites that will be applicable for other Vital Signs. Finally, these five Vital Signs, given our desire to address scale, are particularly well linked ecologically. That is, land use and vegetative cover directly affect water quality (Karr and Chu 1999) for which amphibians may be excellent indicators (Heyer et al. 1993). This allows us an opportunity to explore cause and effect relationships.

The NPS guidelines for developing an integrated monitoring program encourage co-location of sampling (NPS I&M 2004). Protocols developed in this project will be nested, to the extent possible, within a larger sampling framework, similar to the Great Lakes Environmental Indicators project (Danz et al. *in press*). Thus we can assess the association between different components and how they respond to a similar set of stressors (e.g. as land use changes, does water quality, vegetation and amphibian communities also change?). It also allows for interpretation based on multiple lines of evidence. Co-location of samples, however, raises issues of logistics and statistical integrity that need to be addressed by the larger group and discussed with staff at the nine NPS units.

Investigators:

Dr. George Host, senior research associate and director of the natural resource GIS lab at the Natural Resources Research Institute (NRRI), will be the Principal Investigator (PI) of the overall Sampling Design and Protocol Development (SDPD) project. Bill Route, Great Lakes Network Coordinator and vertebrate ecologist, will be co-PI and help to plan, coordinate, and co-development all products. Dr. Host will be joined by Val Brady, research assistant at NRRI, who will assist in coordinating activities among collaborators and ensuring products and deliverables are completed on schedule. The co-PIs are responsible for developing the overall sampling framework and will work closely with Nick Danz, statistician at NRRI, and the Great Lakes Network's Quantitative Ecologist (to be hired in fall 2004). The project will also provide support for one or two bio-statisticians from separate institutions/agencies to review and critique the sampling framework and all protocols on a periodic basis (see below).

Dr. Dan Engstrom, research scientist and director of the St. Croix Watershed Research Station (SCWRS), will be the principal for developing water quality protocols for river systems. Dr. Engstrom will work with SCWRS staff and/or a PhD student. Joan Elias, GLKN Aquatic Ecologist, will be co-principal for developing this protocol.

Dr. Richard Axler, senior research associate and limnologist at NRRI, will be the principal for developing the water quality protocols for lake systems. Joan Elias, GLKN Aquatic Ecologist, will be co-principal for developing this protocol.

Dr. Paul Bolstad, associate professor at the University of Minnesota, will be the principal for developing land use/landscape change protocols. Ulf Gafvert, GLKN GIS specialist, will be co-principal for developing this protocol.

Drs. Don Waller, professor of botany and Tom Rooney, post-doctoral student at University of Wisconsin, will lead the development of terrestrial vegetation protocols. They will work closely with GLKN ecologist Joan Elias and inventory specialist, Dr. Suzanne Sanders.

Dr. Walt Sadinski, research scientist at USGS, La Crosse, WI, and coordinator of the Midwest region Amphibian Research and Monitoring Initiative (ARMI) will be the principal for developing the amphibian monitoring protocols. Bill Route, Great Lakes Network Coordinator and vertebrate ecologist, will be co-principal.

The principal for the database design will be the GLKN data manager (to be hired in 2004) who will collaborate with NRRI data manager Terry Brown, GLKN data specialist Mark Hart, NRRI GIS specialist Gerald Sjerven, and GLKN GIS specialist Ulf Gafvert.

Statistical consultation and review will be coordinated initially by co-PIs, George Host and Bill Route. However, GLKN will hire a quantitative ecologist in fall 2004 and that person will assume much of the statistical oversight and will facilitate outside review as well. A number of statisticians have been identified and one or more will serve as consultants under separate agreement(s). We have contacted Dr. Doug Johnston, USGS, Dr. Paul Giessler, USGS, Dr. Don Stevens, Oregon State, and Dr. Tom Drummer, Michigan Technological University as potential biostatisticians.

National Park Service substantial involvement:

NPS-GLKN staff will be co-principal investigators in the overall project and in the development of individual protocols as stated above. GLKN staff will be responsible for acquiring and making available any needed spatial and tabular data and other information on park-specific monitoring, other resources, and logistics. GLKN staff will facilitate meetings and informal discussions with park staff when necessary. The GLKN Coordinator and staff will facilitate outside peer review and inform all collaborators as to changes in deadlines or deliverables. During the draft and final protocol development stage, GLKN staff will take an active role in co-authoring these documents since they will ultimately be the individuals who will implement them. Further, GLKN staff will co-author manuscripts for technical reports and publications as deemed appropriate for the level of individual involvement (see reference under products and deliverables #4). The data management portion of the project will be developed primarily by GLKN staff with consultation from other collaborators.

Project Administration and Coordination:

Coordination among investigators is critical to project success. The Natural Resources Research Institute will coordinate conference calls every 4-6 weeks to provide project updates, ensure progress and deliverables are on schedule, and address problems and issues. NRRI will also provide an on-line discussion web site to allow 'random-access' discussions on particular issues; subjects will be open for 1-2 weeks to allow investigators to comment on common topics.

Relating protocols to the sampling framework will require exceptionally close communication among investigators. NRRI will coordinate the following meetings: 1) an initial meeting to discuss overall project objectives, identify final monitoring questions for each Vital Sign, review existing protocols used by other agencies, and discuss sample designs for statistical inference (McDonald and Geissler 2004); 2) An interim meeting (~Feb/March 2005) will be used to provide updates from the individual collaborators, discuss integration among components, address data management issues and strategies, and identify practical considerations for monitoring (cost, safety); 3) A summer 2005 meeting to focus on final content and format for documenting and providing for QA/QC of protocols.

Products and deliverables:

All products and deliverables will be held to high scientific standards including statistical rigor, references to pertinent scientific literature, and substantive peer-review. Investigators should obtain in-house review prior to submitting draft and final products for external peer review. The PI and NPS collaborators will be responsible for facilitating external reviews according to NPS I&M guidelines.
To ensure prompt payment of project invoices, NRRI will coordinate with each of the investigators and prepare a brief (1 to 2 page) written quarterly report on the status of each project and submit them to Bill Route.

In addition, the University of Minnesota, Great Lakes-Northern Forest CESU host university, will receive final electronic copies of all related project products for posting on their web, or the URL where the information is located, whichever is appropriate.

The following products will be developed as a result of this collaborative project:

1. Complete monitoring protocols, that meet published NPS guidelines in format and content (see Oakley et al. 2003), for the following Vital Signs:
   - 1.1. Water quality for river systems
   - 1.2. Water quality for lake systems
   - 1.3. Land use/landscape change
   - 1.4. Terrestrial vegetation
   - 1.5. Amphibians

2. A sampling framework including the following elements and products:
   - 2.1. A technical report describing a statistically robust sampling framework for all nine parks in the Great Lakes Network, why it was chosen, why other designs were not chosen (e.g., logistical and cost constraints), how protocols for initial Vital Signs are enhanced by the design, and how future protocols can fit within the design. The report will include documentation of the scientific, statistical, and fiscal constraints and criteria used to select the design. It should highlight the desire to be efficient and statistically rigorous (acknowledge that long-term monitoring will not always provide cause and effect testing, but we must maximize our opportunities to provide ‘weight of evidence’ data to assess ecosystem change). The report will include one or more conceptual models showing how the five Vital Signs are ecologically linked and how measures of various parameters work in concert to serve multiple purposes (e.g., land use metrics will be relevant to water quality, which may be linked to the timing of amphibian reproduction and calling rates). Where possible, causal relationships will be established. The report will also include GIS themes depicting sample plot layout for all five protocols in all nine parks. Each sample plot will be geo-referenced and all themes will be compatible with the ArcIMS web site being developed by Michigan State University (MSU) under separate agreement.
   - 2.2. A summary narrative of the sampling framework (product #2.1) that will serve as a chapter in the Network’s final monitoring plan. This summary narrative will reference the technical report for details and the protocols will be included as appendices.

3. The data management activities will include the creation of an ESRI geodatabase, compatible with current ESRI GIS software (ArcGIS 9 at present). Initial database products may be created in MS Access using the NPS Natural Resource Database Template, and then migrated to data structures compatible with an enterprise geodatabase. The design should

incorporate NPS standards of tabular and spatial data, which can be found at:
http://www1.nrintra.nps.gov/im/datamgmt/database_strategies_v01.doc
http://science.nature.nps.gov/im/gis/standards.htm
http://science.nature.nps.gov/im/datamgmt/docs.htm

The geodatabase will store the tabular attribute data and the spatial sampling design components that will be developed in the other portions of this agreement. Documentation of the geodatabase will include a data model, data dictionary and discussion of how GLKN monitoring data will be input, stored, queried and retrieved from the geodatabase. The data model and geodatabase will be developed in concert with the GLKN data and GIS managers and associated NPS staff. The goal of GLKN is to create an enterprise geodatabase that can be accessed remotely (web) by GLKN staff, the nine network parks, and science partners through an ArcIMS site that is being developed under contract by Michigan State University.

The final data management task will be an outside peer review of the data model and geodatabase. The reviewers will critique the ability of the database to meet the GLKN monitoring goals. The review will be conducted by individuals who meet the approval of the GLKN. The data model and geodatabase are viewed as the starting point for GLKN data storage and access, but it is envisioned that GLKN will modify the solution as the monitoring process matures.

GLKN will be developing a comprehensive data/GIS management plan as part of the NPS I&M Phase 3 process, draft is due on September 30, 2005. The geodatabase model and design proposed in this project needs to be completed within this timeframe, as it will be part of the GLKN data/GIS management plan.

4. At least one, and possibly a series of manuscripts, for submission to scientific journals documenting the significance of key indicators and the scientific rationale behind the sampling framework selected for use by the Great Lakes Network. Authorship will be determined by the principal investigator and network coordinator using criteria as outlined by Dickson et al. (1978).

Schedule:

The working schedule and deadlines for the overall project are listed below and are also illustrated in the timeline that follows. Specific protocol development plans are further presented in the individual Protocol Development Work Plans.

- July 1, 2004 – Project officially begins.
- July 2004 – (date to be determined) Conference call with all lead investigators to initiate the project. The purpose of the call will be to, 1) review the objectives, products, deliverables, and timeline of the project and to make sure all collaborators understand them; 2) set dates for the first collaborators' meeting.
- August 2004 – (date to be determined) Collaborators meeting. This meeting will be attended by all collaborators and NPS project leads. The purpose of this meeting will be to: 1) review the scope of the project, 2) refine specific monitoring questions for each of the 5 Vital Sign protocols, 3) reaffirm the deliverables and deadlines, and 4) discuss how collaborators will work together to ensure products meet professional standards and that we meet the project deadlines.

- September 15, 2004 - The Network's Phase 2 Report must be submitted to the Midwest regional office for advance review before being submitted to the national program office on October 1, 2004. For this report, the PI and NPS lead will prepare a brief status report, which will eventually be chapter 4 in the Phase 3 Report.
- January 2005 – (date to be determined) Collaborators meeting to review two or more sampling frameworks and discuss the relative value and drawbacks of each. We will strive to adopt a framework at this meeting. The PI will then be charged with refining it by March so that it can be incorporated in to individual protocol designs.
- March 2005 – All collaborators will submit an interim status report. This report should represent the full depth and breadth of the work they have accomplished to date. An abstract of this report will be submitted to the NPS Investigator's Annual Report (IAR) web site.
- September 2005 – Complete draft protocols will be submitted for those that are scheduled for completion by the Phase 3 deadline (all but vegetation). By this time a draft data management plan will also be completed. Each of these will be combined with the sampling framework and revised Phase 2 Report as the new Phase 3 Report, which will be submitted to the Network's Technical Committee and select outside reviewers for peer review.
- December 15, 2005 The Network's Phase 3 Report must be submitted. This report will contain the sampling framework as Chapter 4, sampling protocols as Chapter 5 (this will include at least 2 as finals and the remaining protocols in draft form), and a data management plan as Chapter 6.

Invoices for payment (on government form SF270) will be submitted quarterly to Jerrilyn L. Thompson, Great Lakes and Northern Forest CESU, University of Minnesota, 115 Green Hall, 1530 Cleveland Ave, N. St. Paul, MN 55108. Bill Route will confirm adequate progress is being made on the project prior to approving payment.

Literature Cited

Danz, N.P., R.R. Regal, G.J. Niemi, V. Brady, T. Hollenhorst, L.B. Johnson, G.E. Host, J.M. Hanowski, C. A. Johnston, T. Brown, J. Kingston, and J.R. Kelly. Environmentally stratified sampling design for the development of Great Lakes environmental indicators. Environmental Monitoring & Assessment, *In Press.*

Dickson, J.D. and R.N. Conner. 1978. Guidelines for authorship of scientific articles. Wildlife Society Bulletin 6(4):260-261.

Heyer, W.R., M.A. Donnelly, R.W. McDiarmid, L.C. Hayek, and M.S. Foster. 1993. Measuring and monitoring biological diversity – standards methods for monitoring amphibians. Smithsonian Institute Press, Washington D.C. 364 pp.

Karr, J.R., and E.W. Chu. 1999. Restoring life in running waters – better biological monitoring. Island Press, Washington D.C. 206 pp.

McDonald, T.L. and P.H. Geissler. 2004. Systematic and stratified sampling designs in long-term ecological monitoring sites. USGS publication (draft).

National Park Service Inventory and Monitoring 2004. Guidance for designing an integrated monitoring program. science.nature.nps.gov/im/monitor/vsmTG.htm.

Noon, B.R. 2003. Principles of ecosystem monitoring design – conceptual issues in monitoring ecological resources. Pages 27-71 *In* Monitoring ecosystems – interdisciplinary approaches for evaluating ecoregional initiatives. D.E. Busch and J.C. Trexler eds. Island Press 447 pp.

Oakley, K.L., L.P. Thomas, and S.G. Fancy. 2003. Guidelines for long-term monitoring protocols. Wildlife Society Bulletin 31(4):1000-1003.

Route, B. 2003. Results of scoping workshops to identify monitoring issues for National Park units in the Great Lakes Network. U.S. National Park Service, Great Lakes Network Technical Report GLKN/03/07.

Route, B. 2004. Process and results of choosing and prioritizing vital signs for the Great Lakes Network. U.S. National Park Service, Great Lakes Network Technical Report. *In prep.*

Trexler, J.C. and D.E. Busch. 2003. Monitoring, assessment, and ecoregional initiatives: a synthesis. Pages 405-424 *In* Monitoring ecosystems – interdisciplinary approaches for evaluating ecoregional initiatives. D.E. Busch and J.C. Trexler eds. Island Press 447 pp.

Timeline for completing the Sampling Design and Protocol Development project. Highlighting denotes meetings and mutual deadlines and products.

			Calendar Year 2004						Calendar Year 2005											
			Fiscal Year 2004			Fiscal Year 2005											Fiscal Year 2006			
Responsible party	Task	Notes	July	August	September	October	November	December	January	February	March	April	May	June	July	August	September	October	November	December
LULC	Refine questions		x	F																
LULC	Determine extent, classification system, & scale			x	x	x	x	x												
LULC	Gather available data and do field testing						x	x	x	x	x									
LULC	Submit status report and IAR										S									
LULC	Refine and re-test methods										x	x	x	x	x	x				
LULC	Write protocol															x	D	x	x	F
Veg	Refine questions		x	F																
Veg	Review literature and analyze available data				x	x														
Veg	Collaborate on grassland systems						x	x	x	x										
Veg	Submit status report and IAR										S									
Veg	Refine field methods							x	x	x	x	x								
Veg	Conduct field work at APIS/PIRO												x	x	x	x				
Veg	Analyze field data																x	x		
Veg	Write draft protocol																	x	x	D
Lakes	Refine questions	x	x	F																
Lakes	Core indicators protocol			x	x	x	x	D	x	x	F									
Lakes	Submit status report and IAR										S									
Lakes	Advanced indicators protocol							x	x	x	x	D	x	F						
Lakes	Select organisms protocol											x	x	x	x	D	F			
Rivers	Refine questions		x	F	x	x														
Rivers	Assess available information				x	x	x	x	x	x										
Rivers	Submit status report and IAR										S									
Rivers	Design sampling framework									x	x	x								
Rivers	Write protocol											x	x	x	x	x	D	x	x	F
Herps	Refine questions		x	F																
Herps	Review literature		x	x																
Herps	Herp, write-up inventory work				x	x	x	x	x											
Herps	Submit status report and IAR										S									
Herps	Write protocol										x	x	x	x	x	x	D	x	x	F
NPS	Kick off project with 1st conference call		x																	
NPS	Refine questions with Tech Committee	1	x	F																
PI/All	Collaborators meeting #1 (questions)	2		X																
NPS/PI	Write summary for Phase 2 Report	3	x	x	S															
PI/NPS	GIS themes with locations of current monitoring sites	4	x	x	F															
NPS/PI	Examine framework options with Tech. Committee	5			x	x														
PI	Develop sampling framework(s)	6				x	x	x	D	x	F									
PI/All	Collaborators meeting #2 (framework & database architecture)	6							X											
NPS/PI	Provide collaborators with protocol template	7								x	F									
PI/All	Submit status report and IAR	8									S									
NPS/PI	Write data management and GIS plan	9							x	x	x	x	x	x	x	x	D	x	x	F
All	Final draft protocols submitted for Phase 3	10															D	x	x	F
NPS/PI	Phase 3 to WASO for their review	10															x	x	x	X

S = Status report
D = Draft product
F = Final product

Notes:
1) GLKN staff to examine and confirm monitoring questions of interest to parks with park representatives via email and phone calls.
2) First collaborator's meeting to review objectives and deadlines and to refine monitoring questions and make them consistent in detail and scope.
3) PI and GLKN staff to write a brief summary of the overall project objectives, monitoring questions, scope, and status.
4) GLKN staff to provide PI with site locations for all current and relevant monitoring in parks; PI to develop themes and make available to all collaborators.
5) GLKN and PI to meet with NPS Technical Committee to discuss framework options at the Committee's scheduled fall meeting.
6) PI proposes sampling framework for Technical Committee and collaborator review (at collaborator's meeting #2) and final adoption. The database architecture is determined.
7) GLKN staff works with PI to adopt a protocol template; PI advances template to collaborators for their use in writing protocols.
8) All collaborators write a status report with an abstract, which they post to the NPS web-based Investigators Annual Report (IAR).
9) The data management plan is prepared, including fieldnames and relational tables for the 2-3 protocols that will be submitted in final form with the Phase 3 Report.
10) Draft final protocols and drafts of protocols still being developed are all submitted to PI and GLKN for peer review before being incorporated in to the Phase 3 Report.

OVERALL PROJECT BUDGET (budgets for individual protocols are listed in greater detail under each protocol development work plan).

NPS funding to be obligated in federal fiscal year 2004:

	Institution and tentative funding in FY2004					
Objective#	**NRRI**	**SCWRS**	**U of M**	**U of W**	**USGS**[a]	**Statistics and database**[b]
1.a. River water quality		28,000				
1.b. Lake water quality	20,000					
1.c. LULC			20,000			
1.d. Vegetation				25,400		
1.e. Amphibians					24,200	
2. Frame and statistical	13,640					8,000
3. Database and GIS development	14,664					5,000
4. Publications	4,918					
Travel to meetings	4,000	2,000	2,000	2,000	2,000	2,000
Project leadership	14,778					
Subtotals	72,000	30,000	22,000	27,400	26,200	15,000
Overhead @17.5%	12,600	5,250	3,850	4,795	4,035[a]	2,625
Totals	84,600	35,250	25,850	32,195	30,235	17,625
Grand Total for project = $225,755 **Total funding to NRRI for their work and distribution to subcontractors = $177,895**[a,b]						

a = USGS funding will be transferred directly from the NPS through a separate Interagency Agreement between the two federal agencies; an overhead rate of 15.4% applies.
b = Partners and consultants for these tasks will be determined by the Network Coordinator and PI after initial collaborative meetings; associated costs are not part of this agreement.

Individual Work Plans for Protocol Development

The following work plans establish a collaborative effort to develop the five initial monitoring protocols for the Great Lakes Network. Some of the selected Vital Signs (e.g., water quality) have fairly well documented protocols and the task is to refine these protocols to meet our specific needs. Others require pilot studies and comparative work. Hence, the following work plans vary in complexity and approach.

<u>Revisions and modifications:</u>

There are many unknowns in a project of this complexity. Collaborators must begin by refining the monitoring questions, which could lead to unforeseen tasks and costs. We must also consider adding monitoring questions that address linkages between the various Vital Signs. Undoubtedly we will see other needed changes as we struggle through the trade offs between ecological significance, measurability, logistical constraints, and costs associated with measuring each variable. Thus, these individual work plans will be developed more fully after the first collaborative meeting. This will also provide an opportunity to address specific comments from our initial peer review. If changes are not substantial, they will be addressed through revisions to individual work plans with concurrence of the project PI and Network Coordinator. If changes are substantial, leading to altered products, timelines, or costs, then this agreement will be modified.

Protocol Development Work Plan For

Land Use/Land Cover (LULC) to Support Monitoring in Great Lakes National Parks

Parks Where Protocol will be Implemented: The protocols will be implemented in all parks located within the GLKN. Pilot projects, funded under separate agreement, will be conducted in at least SACN, ISRO, and SLBE.

Justification/Issues being addressed: Land use and land cover monitoring was ranked among the top four major monitoring categories. LULC largely sets the template within which other resources exist and function. Habitat, wildlife population health and viability, water and land resources, recreational and scenic value, and many other important park attributes are affected by LULC.

Specific Monitoring Questions and Objectives to be Addressed by the Protocol: the NPS-GLKN staff have identified a set of questions and associated indicators. Although the direction of monitoring has been established, these indicators and questions will be further refined as a part of this project. The current set of questions and indicators, some of which have been grouped for brevity, are listed below. We propose to develop the protocols for collecting processing, and analyzing remotely sensed data to answer these questions, and/or the closely related questions that evolve after further refinement.

1. How are spatial patterns of LULC in and adjacent to parks changing over time?
2. What are the changes in wetland extent and shape over time?
3. What are the rates and directions of change for highly dynamic environments such as bluffs, spits, sand dunes, and high use areas?
4. How are road systems and road use patterns in and adjacent to parks changing over time?
5. How is forest health changing over time?
6. How are campsite size and shape changing over time?
7. How are changes in LULC altering soil moisture retention, stream flow, river morphometry, turbidity, temperature regimes, water chemistry, and lake levels?

Some of the LULC metrics listed for the final three questions listed above may be mapped using currently proven methods. However, many may not, and these questions in part rely on establishing models or relationships between metrics, other measurements, and the indicators of interest. Protocols for estimating the LULC portion of these questions will be developed, but answering the last three questions as posed would require additional, separate research projects that are broader in scope than the activities proposed here, and are not incorporated into the current proposal.

There are additional monitoring questions that may be addressed using remote sensing data. These questions are currently not part of this project. However, as the collaborative effort advances we may further develop this project to answer them if it is deemed necessary and desirable:

Basic Approach:
Four specific attributes of the LULC activities must be defined prior to the design of optimum sampling protocols. These are:

I *Classification system.* The set of desired categories for LULC and other mapped features must be specified. Current guidelines appear to obligate the use of the National Vegetation Classificaton System (NVCS), but the desired levels in the hierarchy must be identified. In addition, some of the indicators may involve urban or built-up LULC classes or other feature types, such as roads, that are not specified in the NVCS.

II *Areal extent(s) to be mapped for each park.* LULC may be required for an area larger than the park boundary, e.g., to encompass watersheds, counties, quads, or some other landscape feature.

III *Frequency of LULC mapping.* A preliminary set of layers and mapping frequencies have been specified by the GLKN. These must be refined along with the indicators as the mapping protocols are developed.

IV *Grain, or minimum mapping unit (mmu), for each LULC activity/map.* These will be determined based on scale or type of imagery required to identify features or to distinguish relevant classes.

The extent, frequency, and grain are interdependent attributes of the classification method. Combined, the specifications of these three must be within current or expected cost constraints given current or expected technologies.

We will take the following steps to develop the core LULC protocol:

1) Refine questions and mapping requirements
We will identify the requirements of (I) through (IV) above for each park.
In discussion with the NPS Lead (U. Gafvert, see below) and other participants in the NPS-GLKN protocol development, we will define I through IV and rank the relative importance. This will help elucidate the ecological value and fiscal costs as tradeoffs among them. For example, an increase in the area extent typically results in a decrease in the grain/mmu due to the cost of sampling additional area. We will seek to establish a small set of scales/extents/grains that provide the required monitoring utility at a limited cost for each of the indicators. We may do this by soliciting an explicit ranking for these various trade-offs, i.e., 1:6,000 every year for all parks not possible, but 1:40,000 based information every 5 years may be useless to some parks. Alternatives will be discussed primarily with GLKN personnel and associated developers of other monitoring protocols to identify these trade-offs, and specify the most cost-effective combination that provides the required information.

2) Define and test methods
We will identify the level of professional sophistication or knowledge required for those who will perform the LULC mapping. This will require developing draft recommendations for image-interpretation for the desired LULC features. These recommendations will include a discussion of the current and expected relative costs and time requirements for acquisition, processing, and analysis, and an indication of the relative level of knowledge required to perform the analysis.

Recommended methods will then be tested for a subset of areas in a subset of parks. This is an expansion of ongoing work (funded under separate agreement) to include a subset of the additional LULC outputs associated with the refined set of indicators. We will identify pilot study areas, (generally small portions of parks), test protocols using a combination of image interpretation, conduct field visits to ground truth, and conduct accuracy assessment based on standard methods employing Cohen's Kappa in contingency tables.

We will also develop image interpretation example guides including document files of paired aerial/ground photos, and of type-images for each of the important LULC metrics. These will be part of the protocols designed to ensure comparability across time, so that interpretation methods and ground truth will be recorded in a set of visual vouchers.

3) Codify protocols
We will develop and deliver a document that clearly states the objectives, methods, grain, and extent for each LULC metrics described, and also provides a detailed description of the steps needed to obtain the correct images, conduct pre-processing, digitize and interpret the images, and attribute, finalize, assess the accuracy, and document (prepare metadata) for the LULC layers. These final protocols will require the iterative development of more detailed questions and cost estimates of the different technologies and professional expertise.

Principal Investigators and NPS Lead: Paul Bolstad, University of Minnesota, Phone: 612-624-9711) is the Principal Investigator; Ulf Gafvert 715-682-0631 x22) is NPS lead for Land Use / Landscape protocol development.

Development Schedule and Expected Interim Products:
August 2004: Refine questions at collaborative meeting.
August 2004-December 2004: Identify classification system, extent, frequency, and grain required for resource management. Identify all pilot project areas, and initial selection of broad methods to use in each pilot project.
November 2004- March 2005: collect image and supporting data, perform initial LULC classification. Initiate field visits for ground truth, data collection. Submit status report and Investigator's Annual Report (IAR)
March 2005 – August 2005. Refine and re-test LULC methods. Begin data collection for accuracy assessment, begin drafting image interpretation example guides, LULC mapping protocols.
August 2005-December 2005. Complete accuracy assessment, image interpretation example guides, and deliver protocols.

Budget: This budget provides for the personnel and travel costs incurred by the University of Minnesota- Twin Cities, Department of Forest Resources. We assume image acquisition costs, are additional, and will be borne by the NPS-GLKN. A substantial amount of data has already been acquired, so additional acquisition costs may be small, however they are as yet unknown. Additional data costs will depend primarily on changes or additions occasioned by the further refinements in protocols.

Line item	**Cost**
Wages and benefits:	
PI wages	$3,050
PI benefits	$950
Staff wages	$10,675
Staff benefits	$3,325
Travel:	
Collaborative meetings	$2,000
Equipment and supplies:	
Equipment	$ 800 (field data logger/GPS)
Supplies	$1,200 (photos, film carriers, electronic media, film)
Subtotal	$22,000
Overhead @ 17.5%	$3,850
Total subproject	$25,850

Protocol Development Work Plan For

Terrestrial Vegetation Structure and Dynamics

Parks Where Protocol will be Implemented:
These protocols are being developed for and will eventually be implemented in all Parks in the region (APIS, GRPO, INDU, ISRO, MISS, PIRO, SACN, SLBE, and VOYA).

Justification/Issues being addressed:
The GLKN ranked terrestrial vegetation 3rd among all the vital signs they evaluated with good reason. When combined with other vital signs, vegetation monitoring provides key data on ecosystem health. Such data are important for several reasons including:

1. Vegetation integrates and expresses information about geology, hydrology, soils, disturbance, and climate.
2. Vegetation represents the trophic base for all ecosystem processes and primary habitat for all animal species.
3. Vegetation data capture information about ecosystems (productivity, C storage, etc.), communities (structure and function), and plant guild and species composition.
4. Plant communities can be sampled directly in the field, providing many sample points on many species (dozens to hundreds). Such data provide sensitive metrics for tracking many types of ecological change over time at particular spatial scales.

Goals and Objectives:
To make sound management decisions, National Park Service (NPS) managers need to know how natural systems change over time and what kinds and rates of change fall within the natural range of historic variability. The vegetation monitoring protocols and networks we propose to develop should provide key data that will grow increasingly valuable with long-term monitoring. These efforts should also identify key 'vital signs' capable of providing early warning signs of impending declines in ecosystem integrity. Such early detection of potential problems should allow park managers to take timely action before solutions become ecologically, economically, socially, or politically intractable. We focus on three broad questions central to the vegetation monitoring program:

• How is plant community composition changing over time?
• How is the structure of terrestrial plant communities changing over time?
• How are plant communities responding to anthropogenic and natural disturbances?
The latter include widespread increases in weedy invasive plants and levels of deer herbivory.

Specific Monitoring Questions and Objectives to be addressed by the Protocol
To determine which protocols work best generally and specifically on the habitat types to be surveyed in the nine Great Lake National Parks, we pose the following specific questions:

1. *What goals and concerns should be addressed?* Before developing specific protocols for vegetation monitoring, we plan to consult with biologists at each Park (in person or via a survey) to identify the biotic issues of most concern, the goals they would like to see addressed, and particular concerns or needs. **Justification**. Such information is needed to

guide our subsequent work and is vital if we are to design monitoring protocols of interest and need to Park personnel.

2. *What monitoring resources exist?* We plan to survey existing monitoring programs in the region, noting methods used, data available, longevity and continuity. We will also tally local and regional resources available for current monitoring. **Justification**. Information on previous and current monitoring the region is crucial if we are to design a long-term monitoring program that can take advantage of existing historical data and allow statistically valid comparisons to similar data being compiled elsewhere in the region. We need to assess the potential of two large data sets, in particular, to contribute to this monitoring protocol: the Forest Inventory and Analysis (**FIA**) protocol of the U.S. Forest Service used since 1930 primarily to census timber resources, and the extensive vegetation sampling first conducted by John Curtis and the Plant Ecology Laboratory (PEL) at the Univ. of Wisconsin-Madison in the 1950s and continued recently by other UW researchers (see below). We also plan to assess the protocols and value of existing citizen science monitoring programs (e.g., for exotics) to see whether these can complement NPS efforts. Finally, we need to assess the total resources available for monitoring if we are to design a practical achievable scheme.

3. *How should monitoring efforts be tailored to, and distributed among, vegetation types?* **Justification**. Vegetation maps reveal a range of vegetation types and conditions that often demand different survey scales or methods. These types may also deserve some different intensity or frequency of monitoring. In addition, Parks would benefit by being able to integrate the data to be generated via ground surveys of vegetation to the monitoring (GIS) data generated on *land use and landscape change* by Paul Bolstad's program.

4. *How should we characterize plant species composition (abundances and diversity of nativeand exotic herbs, shrubs, and trees)?* **Justification**. Our goal is to efficiently and reliably characterize plant species composition, including the abundances and diversity of native and exotic herbs, shrubs, and trees, in the major vegetation types present. These data are our foundation for evaluating shifts in species richness, floristic quality, the abundance of exotics, and composition over time. However, a variety of sampling techniques exist for surveying various components of vegetation. These need to be tested in the field and compared for their suitability for this monitoring program.

5. *How do the relative frequencies of trees, shrubs, and herbaceous plants and the guilds they represent change over time and between sites?* In addition to tracking the distribution and abundance of many plant species, it is also important to track the functional groups and guilds that these species represent. We propose to do this by categorizing species by foliage type (evergreen vs. deciduous), forage class (graminoids, forbs, woody), pollination mode (insect vs. wind pollinated), etc. **Justification**. Increases in graminoids in forest habitats often reflect increases in ungulate grazing pressure and may thus provide an early warning sign of incipient declines in species richness. Similarly, increases in woody plants in prairies and savannas often indicate fire suppression or the absence of other key disturbances.

6. *How can we most efficiently track differences in stem density, basal area, and the amount of standing and down woody material over sites and time?* **Justification**. The physical

structure of communities influences habitat suitability for a number of birds, mammals, plants, and detritivores. Percent cover and basal area also reflect habitat productivity, while coarse woody debris may reflect overall levels of carbon storage.

7. *How do plant communities respond to natural disturbances, deer impacts, and anthropogenicstress?* **Justification**: The dynamics of terrestrial plant communities are driven by various natural and anthropogenic disturbances as well as interactions with keystone herbivores like deer. Changes in these processes have important implications and generally shift community structure or composition. In addition, because vegetation typically responds rapidly to disturbance, it is important to disentangle such local transient responses from systematic continuing or regional shifts in vegetation.

Basic Approach

We will use a combination of approaches to address the questions raised above (Table 1). Several questions (e.g., 1, 2, and 5) can be addressed using existing resources. These include Park records, the literature, vegetation maps, statistical simulation, and biologists with suitable expertise. In other cases (questions 4 and 6), we need more information from actual field surveys to assess the suitability of alternative approaches to monitoring. We therefore propose field surveys in two Parks (APIS and PIRO) to evaluate and compare existing survey techniques (see **Appendix**).

Such comparisons will allow us to determine the most efficient and informative protocols for particular habitat types and to estimate the sample sizes or intensity of sampling needed to characterize diversity and other variables of interest. These field results will then be combined with basic concepts from statistical sampling theory and knowledge of other monitoring programs to design specific protocols. Although our field comparisons focus on the forest sampling protocols, we also plan to design protocols for monitoring grassland and dune habitats as a secondary priority, consulting with Noel Pavlovic (USGS) and others with extensive experience with these communities. In addition, we consider it important to coordinate regional NPS monitoring efforts with activities associated with the new NSF-sponsored National Ecological Observatory Network (NEON). This will be discussed next at a regional meeting at the Univ. of Michigan Field Station at Douglas Lake in Oct. 2004 we plan to attend. While it is our hope and expectation to complete draft final protocols for monitoring vegetation in all habitat types by the Dec. 2005 deadline, the need to analyze data from summer 2005 may delay this. In that event, we would submit an Interim Report on the pilot studies and including only a working draft of the protocols.

Table 1. Approaches to be used to address specific monitoring questions

Question	Approach
1. What goals and concerns should be addressed?	Interview biologists at each Park to identify the biotic issues of most concern, the goals they would like to see addressed, and particular concerns or needs.
2. What monitoring resources exist?	Review existing monitoring programs in the region, noting methods used, data available, longevity and continuity. Attend regional NEON planning meeting (Oct 04). Tally local and regional resources available for monitoring.
3. How should monitoring efforts be tailored to and distributed among vegetation types?	Review existing resources and literature to assess the extent and types of vegetation from existing vegetation maps. Estimate resources needed to sample each type and prioritize monitoring needs and opportunities.
4. How should we characterize plant species composition (abundances and diversity of native and exotic herbs, shrubs, and trees)?	Review existing methods for surveying each type of vegetation. Estimate sample sizes needed to achieve various levels of certainty based on existing data. Conduct field tests to determine the relative feasibility and efficiency of particular methods including those of the FIA and PEL (see below). Estimate sample sizes, time, and resources needed to reliably characterize plant community composition.
5. How do the relative frequencies of trees, shrubs, and herbaceous plants and the guilds they represent change over time and between sites?	Compile and compare data on how plants are categorized into functional groups and guilds. Prepare databases to systematize these assignments. Analyze preliminary data to assess sample sizes needed to detect trends. Declines in species richness or floristic quality, or increases in exotic species, indicate declines in habitat quality.
6. How can we efficiently track differences in stem density, basal area, and the amount of standing and down woody material over sites and time?	Review existing methods for surveying stems, BA, and CWD in various community types. Conduct field trials to assess efficiency and reliability. Integrate these sampling techniques with other monitoring methods to streamline field surveys.
7. How do plant communities respond to natural disturbances, deer impacts, and anthropogenic stress?	Explore methods to record disturbance events during vegetation surveys and track associated changes in vegetation. Assess whether size (demographic) structures of trees and particular herbs can be used to assess failures in regeneration.

Principal Investigator and NPS Lead:
PI: Donald M. Waller, Department of Botany, 430 Lincoln Drive, Madison WI 53706
608-263-2042; dmwaller@wisc.edu; http://botany.wisc.edu/waller/homogenized/
NPS Lead: Joan Elias, GLKN (715-682-0631 x24)

Schedule:

Fall 2004	Review sampling methods, reports, and theory Conduct power analysis to identify necessary sample sizes Attend Oct. NEON meeting (U. Michigan)
Winter 2004-05	Consult with Noel Pavlovic & others on sampling grassland systems Finalize draft FIA and PEL protocols for sampling
Spring 2005	Provide status report
Summer 2005	Train field teams; resurvey APIS and PIRO sites
Fall 2005	Analyze & interpret data Revise draft protocols with justifications Prepare final or interim report to NPS
Winter 2005	Provide recommended draft protocol
Spring 2006	(Deliver final report to NPS if necessary) Submit APIS changes manuscript for peer-reviewed publication

Development Schedule and Expected Interim Products: When this project is complete, we will evaluate both monitoring systems, and make a written recommendation in final report form based on the efficiency of data collection and statistical power and perceived relevance of the measured variables. Our final report will follow the guidelines for long term monitoring protocols and standard operating procedures outlined by Oakley et al. (2003). We expect to publish the 50-year APIS changes in a separate publication.

Budget:

Line item	**Cost**	
Wages and benefits:		
PI	$ 0	
Others	$20,900	(grad. student &/or post-doc + assistant)
Travel:		
Collaborative meetings	$ 2000	
Field work	$ 3600	
Equipment and supplies:		
List major equipment	$ 0	
Group supplies in 1 line	$ 900	(Pocket PC, GPS, tapes, flagging, etc.)
Subtotal	$ 27,400	
Overhead @ 17.5%	$ 4795	
Total subproject	$ 32,195	

References Cited

Beals, E. W., G. Cottam, and R. G. Vogel. 1960. Influence of deer on the vegetation of the Apostle Islands, Wisconsin. J. Wildlife Management 24: 68-80.

Curtis, J.T. 1959. The vegetation of Wisconsin. University of Wisconsin Press, Madison, Wisconsin, USA.

Oakley, K.L., L.P. Thomas, & S.G. Fancy. 2003. Guidelines for long-term monitoring protocols. Wildlife Society Bulletin 31: 1000-1003.

Rooney, T.P., S.M. Wiegmann, D.A. Rogers, & D.M. Waller. 2004. Biotic impoverishment and homogenization of unfragmented forest understory communities. Conservation Biology 18: 787798.

APPENDIX: Comparisons of sampling techniques.

We propose to compare several sampling methods that differ in their emphasis and thus sensitivity for detecting various kinds of ecological change. These include various methods used to sample grassland and dune habitats (to be determined) plus variants of two long-standing protocols used to sample forest vegetation. The forest vegetation sampling methodologies are already well established in the Midwest and thus deserve careful scrutiny for adaptation into protocols for monitoring Midwestern National Parks. The first is the Forest Inventory and Analysis (FIA) protocol developed by the US Forest Service in the 1930's used throughout the National Forests to monitor tree growth and timber volumes. The second represent the methods used by Curtis (1959) and colleagues involved with the Plant Ecology Laboratory (PEL) surveys of vegetation in Wisconsin in the 1940s and 50s.

We have three goals in comparing these two survey protocols. First, these surveys would generate preliminary data for evaluating long-term change at two Parks, allowing comparisons to historical baseline data present for APIS (PEL) and PIRO (FIA). Second, these field experiences would allow us to compare the efficiency and reliability of these two protocols, evaluating trade-offs between the statistical power of trend detection and the quality and quantity of data produced. Finally, the use of methods already in widespread use in the region would allow contemporary comparisons between Park data and geographically broader data sets representing other ownerships. Here, we first provide background on each approach then outline the comparisons we plan to make between them based on data we would collect from these two Parks in summer 2005.

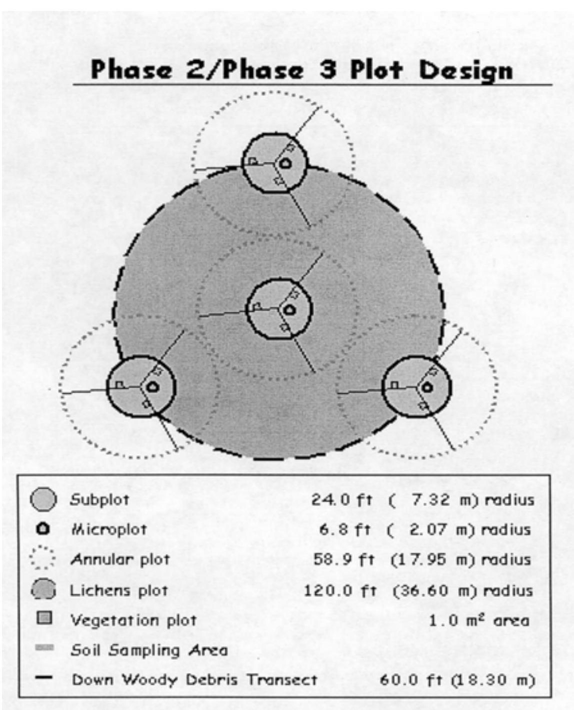

Fig 1. FIA Phase 2 and Phase3 plots, layout and design.

The U.S. Forest Service has used variants of the FIA protocol since 1930 to provide inventory and analysis of the present and possible future conditions of forest conditions across the United States. This protocol was specifically designed to census tree growth and standing timber stocks for policy development and public education and outreach. However, it has been since been extended to include data on other forest ecosystem elements using a three-tiered approach. First, a broad, remote sensing approach classifies land into forest or nonforest. Second, a comprehensive "Phase 2" plot placed every 6000 acres samples tree composition, diameter, and a number of silvicultural variables on the ground. Finally, a detailed "Phase 3" plot (at 6.25% of all Phase 2 plots) samples all vegetation, forest health indicators, coarse woody debris, and soils (Fig. 1). The power of FIA sampling comes from replicating study plots over a broad area. Thus, FIA sampling within National Parks would generate data that could be compared to USFS sites throughout the Great Lakes region to determine whether forest changes observed within the Parks track broad regional trends or are specific and novel to the Parks. Limitations of the FIA data include the use of only a few quadrats to sample understory herbs (where most plant diversity occurs) and limited information on tree seedling/sapling numbers and thus recruitment.

To comprehensively describe the types of vegetation present in Wisconsin, John Curtis (1959) initiated the PEL research program involving dozens of graduate students over a 20 year period. They eventually sampled several different habitat types at 1420 sites throughout the state. At the onset of the project, they realized that the standard sampling design used by most vegetation researchers (10 x 10 m plots) would take too much time and money to sample. This led them to develop point-based sampling methods which allowed them to sample a large number of stands quickly. The original PEL sampling collected data at fixed points 6-8 m apart along a U-shaped transect (Fig. 2). At each of 20 (or 40) points, field teams collected data on tree size, density, and composition using the random pairs method. They also recorded the presence of all vascular herbaceous plants and shrubs in a 1-m^2 quadrat. This method accurately reflects patterns of distribution and abundance of the common and intermediate species, but the limited number of quadrats fails to capture information on the rare species present at each site (Curtis 1959). PEL sampling method was developed for forests, but the basic sampling strategy was extended to prairies, savannas, lake dunes, cliffs, and wetlands.

Over the past 5 years, our research group has relocated and resurveyed over 200 forested PEL sites in S and N Wisconsin. We extended the original PEL methods, primarily to increase the number of quadrats sampled for herbs and to better sample shrubs and saplings. We have also worked out many sampling, taxonomic, and data management issues involved in synchronizing the data sets and for comparing data among sites and between periods when sample sizes or methods may differ. We find that although significant change is difficult to observe within most sites, regional data in aggregate provide a compelling picture of ecological change. These methods allowed us to conclude that overall species richness and animal pollinated plants in particular are declining in N Wisconsin, while native habitat generalists and non-native invasive plants are increasing, resulting in biotic impoverishment (Rooney et al. 2004). Thus, PEL methods are also attractive for providing comparisons with these sites across a 50 year period. However, they, too, leave certain gaps (e.g., they place less emphasis on crown condition – Table 2).

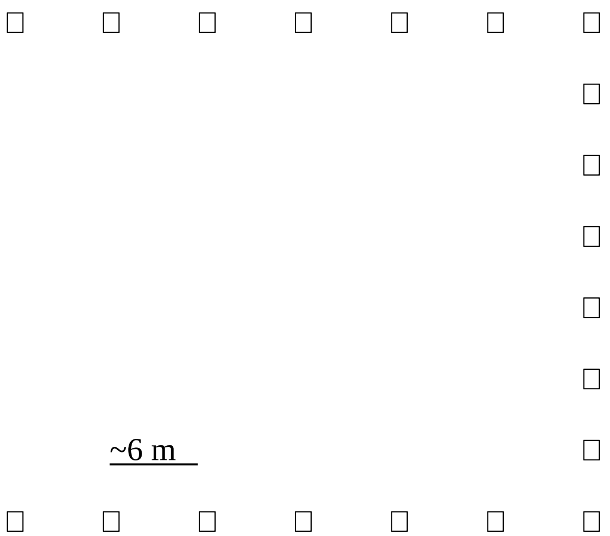

Fig 2. Layout and design of PEL plots. Each square represents a 1 x 1 m quadrat sampled for herbs, shrubs, and tree seedlings. At each square, tree size, density, and composition are recorded. The plot can be replicated within sites to improve the sampling precision and accuracy.

Table 2. Variables measured with each sampling technique. Both techniques have been modified since their origin to include additional data. This table presents the data available in recent versions of the sampling protocols.

Variable	**PEL**	**FIA**
1. Trees		
species composition and importance value	Yes	Yes
crown condition	No	Yes
seedling and sapling numbers	Yes	Yes
2. Shrubs & saplings		
species composition and importance value	Yes	Yes
3. Herbaceous layer		
foliage type (deciduous vs. evergreen)	Yes	Yes
4. Vines		
vine type (twiners, graspers, lianas)	Yes	Yes
5. Community-level data		
floristic quality (mean coefficient of conservatism)	Yes	Yes
% exotics in flora	Yes	Yes
importance value of exotics	Yes	Yes
importance value of graminoids	Yes	Yes
species richness	Yes	Yes
6. Habitat structure		
coarse woody debris (by size and decay class)	No	Yes
snag density (by size)	No	Yes
vegetation height (by strata)	No	Yes

Note: Both techniques identify species, allowing assignment of functional characters including:
foliage type (evergreen vs. deciduous)
pollination mode (insect vs. wind pollinated)
fruit type (fleshy vs. hard)

Proposed field comparison of sampling protocols: We propose to collect and compare vegetation data from two national parks in the Great Lakes Region: **APIS** and **PIRO**. In particular, we propose to exploit the existence of over 70 historic PEL sites at APIS (see Beals et al. 1960) and a dense concentration of 100 FIA sites at PIRO to perform side-by-side comparisons of the techniques. In each of these Parks, we will establish, permanently mark, georeference, and sample adjacent or over-lapping PEL and FIA plots following current PEL and FIA protocols. At APIS, we will re-locate and re-sample at least 12 PEL sites sampled by Beals et al. using both protocols. At PIRO, we will locate new PEL sampling sites at 12 or more locations where Bruce Leutscher has already established and sampled FIA plots. In the FIA plots, we will sample canopy trees; snags and crown conditions in subplots; shrub, vine, and vertical structure data in the microplots; and herbaceous data in the vegetation plots. We will sample coarse woody derbis along the down woody debris transects (Fig. 1). We will time how long it takes to perform each component of both protocols and note any difficulties or problems particular to either. We will then derive and report a set of vital sign variables (including those listed in Table 2) from both sampling protocols. This will allow direct comparisons of times, mean estimates, and estimated sampling accuracy.
Voucher Specimens: Any specimens collected will be deposited in the State Herbarium of Wisconsin (in Madison) or park collection. Voucher specimens will not be collected for any state or federal threatened, endangered, special concern, or candidate species.

Analyses

In addition to comparing contemporary data, the proposed sampling will also permit comparisons with the broader set of historical data present both at these particular sites (PEL data in APIS and FIA data in PIRO) and regionally. These comparisons will allow a preliminary inspection of long-term trends in each Park. Some variables are doubtless sensitive to local conditions and vary quickly over time and space. Other variables are more integrative and only change slowly. We will also conduct power analyses to determine how great the changes need to be (within and among replicate sites) to statistically detect trends reliably with 90%, 95%, and 99% levels of confidence. Although detecting change at single sites typically require large sample sizes or catastrophic change, pooling sites makes detecting trends much more sensitive. Categorical variables will be assessed using frequency-based approaches; whereas quantitative variables will be assessed using appropriate parametric and nonparametric methods. As power is a function of sample size and magnitude of response, we will provide charts showing relationships between the magnitude of change and the sample size needed to demonstrate significance. These, in turn, will allow us to make informed decisions on the final monitoring protocols.

Protocol Development Work Plan

Monitoring Water Quality in Lakes

Parks Where Protocol will be Implemented: APIS (Apostle Islands National Lakeshore), GRPO (Grand Portage National Monument), INDU (Indiana Dunes National Lakeshore), ISRO (Isle Royale National Park), MISS (Mississippi National River and Recreation Area), PIRO (Pictured Rocks National Lakeshore), SACN (St. Croix National Scenic Riverway), SLBE (Sleeping Bear Dunes National Lakeshore), and (VOYA) Voyageurs National Park. These parks are all part of the GLKN (Great Lakes Inventory and Monitoring Network).

Justification/Issues being addressed: The National Park Service's Great Lakes Network (NPS-GLKN) has developed a prioritized list of 46 indicators, termed *Vital Signs*, for monitoring long-term ecosystem health for nine NPS units in the Great Lakes region. In February of 2004, a Focus Workshop on *Vital Signs* for aquatic resources within the GLKN was held and was attended by GLKN staff along with invited external experts in the areas of aquatic biology and ecology, and limnology who were charged with prioritizing and refining a list of candidate Vital Signs for GLKN aquatic systems. A "core suite" of key water quality parameters - temperature, pH, conductivity, dissolved oxygen, and water level- that had been previously identified by the NPS-WRD as central to all NPS freshwater, and potentially marine/estuarine, monitoring programs was affirmed to be central to any monitoring program. Exotic species was ranked equally high among the potential *Vital Signs* evaluated during the workshop. In addition to the core suite and exotic species, an "advanced suite" of water quality parameters that included water clarity/turbidity, organic and inorganic contaminants, nutrients and major ions, ranked among the top ten potential *Vital Signs* evaluated. "Pathogens" (fecal indicator bacteria and certain cyanobacteria) are essential indicators at high use public beaches. "Sediment characteristics (nutrients, diatoms, texture, organic matter)" are another subgroup of the Water Quality group that represent integrative measures of biological communities and water column characteristics (e.g. diatoms, nutrients, contaminants, etc) as well as important ancillary habitat information. An additional important subgroup of *Vital Signs* is the Aquatic organisms (species, populations and communities) subgroup that is most directly linked to the "fishable/swimmable" goal of the federal Clean Water Act. Besides providing direct measures of the overall condition of native communities and species, these may be useful for identifying aquatic nuisance/invasive species and the status of threatened and endangered species. It is important to note that these *Vital Sign* rankings reflect the workshop participants' perception of the suitability and utility of a given parameter or metric, as a measure of water quality, based on its ecological significance as well as measurability/sensitivity.

Specific Monitoring Questions and Objectives to be Addressed by the Protocol:
The following questions were developed based on the PI's current understanding of the status of the Candidate Vital Signs prioritization process which included the February 2004 Workshop noted previously. They were developed in collaboration with the NPS-GLKN lead but may be modified during the conduct of this grant according to changes that develop as a part of the Vital Signs review process still in progress.

1) Water Quality -Core Suite: What, if any, is the magnitude and direction of change in the core suite of water quality parameters? (Metrics: water temperature, specific electrical

conductivity, pH, dissolved oxygen, lake level). **Justification-** These were previously established by a national review panel assembled by the NPS-WRD that recommended the core water quality suite be measured across all NPS monitoring networks. The core suite was ranked highest among potential *Vital Signs* for aquatic systems although it was recognized that these measurements were likely to be less diagnostic than the "advanced suite" of water quality metrics (see below).

2) Water Quality- Advanced suite: What, if any, is the magnitude and direction of change in the advanced suite of water quality parameters? (Metrics: water clarity/turbidity, organic and inorganic contaminants, nutrients and major ions). **Justification**- The advanced water quality suite includes widely accepted measures of water quality sensitive to a variety of stressors that affect the condition of aquatic resources. These metrics were determined to be fundamentally important to assessing the condition of lakes by the participants in the Workshop and are included in most state and federal lake monitoring programs

3) Aquatic organisms (specifically planktonic and benthic organisms): What, if any, is the magnitude and direction of change in lake biological communities, in particular those with high diagnostic potential (e.g., for algae - chlorophyll-a , rapid scans, and surficial sediment diatom community structure), high nuisance potential (noxious cyanobacteria), and introduced/invasive species. **Justification-** A primary goal of maintaining acceptable water quality is to protect indigenous species. Direct monitoring of chemical water quality parameters is costly and may not be as cost-effective as biomonitoring.

   Note – this is a large category and includes planktonic and periphytic algae, zooplankton, benthic invertebrates, mussels and crayfish, fish and aquatic vegetation. Protocol development for all of these, particularly the larger organisms, is likely beyond the scope of this proposal although we would work cooperatively with NPS-GLKN staff to identify applicable protocols from pre-existing monitoring programs.

Basic Approach:
1) *Refine Monitoring Questions:* We have not yet seen the results of the prioritization effort from scientists and resource managers from the February 2004 GLKN Workshop or their integration with Park Management scores. This information is essential to focus our efforts on priority protocols.

2) *Identify and assess existing GLKN datasets and monitoring programs and ongoing state, federal and tribal monitoring programs:* Our basic approach will be to assess existing protocols being used across the GLKN in regard to:

A. Their utility in assessing water quality trends (this is funded under a separate agreement)
B. Identifying field and laboratory equipment and levels of training available to park personnel
C. Identifying existing water quality (and related aquatic organism and community) monitoring programs in the region noting methods used, goals and cost-effectiveness. Since integration of GLKN data with current and future monitoring data collected by other agencies is desirable, we will identify and review relevant State, Federal and

Tribal programs including methods currently being evaluated by the NRRI-UMD directed Great Lakes Environmental Indicators (GLEI: http://glei.nrri.umn.edu) project that is evaluating biological indicators of the health and ecological integrity of the Great Lakes coastal zone. Some of the relevant programs are described in: Paulsen et al. 1991, Hedtke et al. 1992, Klemm et al. 1993, Collins 1995, Chaillou et al. 1996, Bertram and Stadler-Salt 1999 (SOLEC), MPCA 2003; Oakley et al. 2003, USGS-NWQA 2004. These have been nearly uniformly accepted by federal and state resource and regulatory agencies. A further set of WQ monitoring programs exist based on volunteer effort may be useful for incorporation into park programs (e.g., EPA 1996) and various state citizen lake monitoring programs. EPA (NPDES, CWA, National Surface Water Survey and Acidic Deposition related Surveys, EMAP, et al.), USGS-NWQA (2004 Index) and APHA (2003) offer compilations of standardized and nearly uniformly accepted analytical and field methodologies.

3) *Specific protocol development (field and laboratory):* We will synthesize the resources described above and recommend detailed methodologies for sampling and analytical measurements that are scientifically established, amenable to accepted Quality Assurance and Quality Control procedures, logistically feasible, and cost-effective. Protocols will include standardized bottle preparation, sample collection, handling, and storage, analytical laboratory selection, and levels of detection required for each method. Quality assurance and quality control procedures will also be developed for use across the GLKN. In addition, PI Axler has been the lead for part of a water science curriculum development project that is generating on-line training modules for many of the techniques likely to be recommended for the GLKN. These are readily downloadable from the Water-on-the-Web website (http://waterontheweb.org) and should be useful for training purposes (WOW 2004).

4) *Establish monitoring framework:* The selection of sampling sites will be an extremely important subtask in protocol development requiring input from NPS Unit and GLKN staff, the stream monitoring protocol group and the overall sampling framework group. It will need to include consideration of local, site-specific geographic variability in WQ parameters and complement ongoing monitoring efforts within park units as well as within the region – e.g., ecoregion lake monitoring efforts by the Minnesota Pollution Control Agency or each state's Department of Natural Resources. Because of the large number of potential lake sampling sites in the GLKN, the effort will focus on development of site selection criteria based on other large-scale monitoring programs (e.g., EPA-EMAP and USGS-NWQA).

References

APHA. 2003. Standard methods for the examination of water and wastewater. American Public Health Association, Washington, D.C.

Bertram, P. and N. Stadler-Salt. 1999 (a more current document may exist). Selection of Indicators for Great Lakes Ecosystem Health. State of the Lakes Ecosystem Conference, Buffalo, New York.

Chaillou, J.C., S.B. Weisberg, F.W. Kutz, T.E. DeMoss, L. Mangiarcina, R. Magnien, R. Eskin, J. Maxted, K. Price, and J.K. Summers. 1996. Assessment of the Ecological Condition of the Delaware and Maryland Coastal Bays. Washington, D.C. US Environmental Protection Agency, ORD. Report EPA/620/R-96/004.

Collins, G. 1995. Environmental Monitoring and Assessment Program (EMAP) Methods Format Guide. US EPA Environmental Monitoring Systems Laboratory, Office of Research and Development, Cincinnati, OH 45268. EPA/620/R-95/001, March 1995.

EPA. 1996. The Volunteer Monitor=s Guide to: Quality Assurance Project Plans. 1996. EPA 841-B-96-003, Sep 1996, U.S. EPA, Office of Wetlands, Washington, D.C. 20460, USA (http://www.epa.gov/owowwtr1/monitoring/volunteer/qappexec.htm).

Hedtke, S., A. Pilli, D. Dolan, G. McRae, B. Goodno, R. Kreis, G. Warren, D. Swackhamer and M. Henry. 1992. EMAP - Great Lakes Monitoring and Research Strategy. Duluth: US Environmental Protection Agency, ORD, ERL. Report EPA/602/R-92/001.

Klemm, D.J., L.B. Lobring, J.W. Eichelberger, A. Alford-Stevens, B.B. Porter, R.F. Thonmas, J.M. Lazorchak, G.B. Collins and R.L. Graves. 1993. Environmental Monitoring and Assessment Program (EMAP) Laboratory Methods Manual: Estuaries. Cincinnati: US Environmental Protection Agency, ERL.

Minnesota Pollution Control Agency. 2003. Guidance manual for assessing the quality of Minnesota surface waters for the determination of impairment. January 2003.

Oakley et al. 2003. Guidelines for long-term monitoring protocols. Wildlife Society Bulletin 31(4):1000-1003).

Paulsen, S.P. et al. (14 co-authors). 1991. EMAP-Surface waters- Monitoring and research strategy-FY1991. U.S.Environmental Protection Agency, ORD, Washington, D.C.

USGS- NWQA. 2004 (Index). National Water Quality Assessment Program Protocols: http://water.usgs.gov/nawqa/protocols/doc_list.html . US Geological Survey, Washington, D.C.

WOW. 2004. *Water-on-the-Web*: Advanced technologies and real-time data in basic and water science: A national curriculum for colleges and high schools - http://waterontheweb.org .

Principal Investigators and NPS Lead:
Protocol development will be conducted through a cooperative agreement with the Center for Water and the Environment, Natural Resources Research Institute (5013 Miller Trunk Highway, Duluth, MN 55811). Principal investigators will be Richard Axler (raxler@nrri.umn.edu; 218-720-4316) and Joseph Mayasich (jmayasic@nrri.umn.edu; 218-720-4325). The National Park Service lead will be Joan Elias (joan_elias@nps.gov; 714-682-0631).

Development Schedule and Expected Interim Products (draft subject to revision):

July 2004 - Project start date
August 2004 - Refine monitoring questions at meeting
October 2004 - Compile information on existing monitoring programs
December 2004 - Draft protocols for core WQ suite
January 2005 - Meeting to discuss framework
March 2005 - Revision of protocols for core WQ suite
March 2005 - Status report
April 2005 - Draft protocols for advanced WQ suite
June 2005 - Revision of protocols for advanced WQ suite
August 2005 -Draft protocols for select aquatic organisms
September 2005 - Final draft of all protocols for peer review
December 2005 - Final submission

Budget:

Line item	Cost
Wages and benefits:	
PI	$6,324
Others	$12,706
Travel:	
Collaborative meetings	$2,000
Project-specific	$200
Equipment and supplies:	
Major equipment	$ -0-
Supplies	$770
Subtotal	$22,000
Overhead @ 17.5%	$3,849
Total subproject	$25,849

Protocol Development Work Plan for

Water Quality for Rivers

Parks Where Protocol will be Implemented: SACN, MISS

Justification/Issues being Addressed:
Large temperate rivers around the world, including the river-based National Park units in the Great Lakes Network (GLKN), have been historically impacted by human activities and face an uncertain future in which water quality is further threatened by climate change, urban development, agriculture, recreation, and transportation uses. Key water quality concerns include (1) excess nutrients (N & P) from urban and agricultural runoff and waste-treatment facilities; (2) sediment loading from stream-bank and field erosion; (3) invasion of exotic species such as carp and zebra mussels; (4) environmental contaminants, especially those of emerging concern – PDBEs, mercury, and endocrine disrupters; and (5) changes in flow regime caused by climate change as well as hydrological impacts from farming and urban growth.

Specific Monitoring Questions and Objectives to be Addressed by the Protocol:

This monitoring protocol will address questions related to the physical, chemical, and biological condition of large rivers in the GLKN:

- What is the rate and direction of change in core water quality parameters in the main stem of the St. Croix and upper Mississippi rivers and their major tributaries?
- Are there long-term systematic changes in flow regime (flood frequency/intensity; annual flows)?
- Are nutrient concentrations and loadings in these rivers and tributaries changing over time and are these driving changes in biological productivity?
- Is the composition and diversity of aquatic-based biotic communities changing, especially among taxonomic groups of special concern (e.g. native mussels, fish, amphibians)?
- Are aquatic nuisance species (ANS) populations changing and are areas of infestation expanding? Are new ANS invading?
- What are the trends in critical or emerging environmental contaminants, especially in upper levels of the food chain (fish or fish-eating wildlife)?

1. Determine changes in core water quality parameters in river main stem and key tributaries (temp, pH, conductivity, DO). ***Justification****: The core water quality suite will be measured across all NPS monitoring networks and ranked highest among potential vital signs for aquatic systems. Although less diagnostic than advanced suite parameters, these data are important physical characteristics of surface waters that are needed to interpret other chemical and biological trends.*
2. Determine flow – continuous or at specific time intervals – in river main stem and key tributaries. ***Justification****: Flow is the key parameter for physical conditions in rivers and is needed to interpret concentration data and calculate loadings. Although part of the core water quality suite, it is singled out here because flow measurement is operationally different from other water quality monitoring. Flow regimes have been historically*

altered by land-use changes and may continue to be impacted by shifting agricultural practices, expanding urbanization, and climate change driven by green-house warming.

3. Determine changes in nutrient (N & P) concentrations and loadings in river main stem and key tributaries. ***Justification**: Excess nutrients and their effects on biological communities are among the most serious threats to large river systems; expanding urbanization, agricultural intensification, and management efforts to mitigate these impacts are likely to change nutrient levels in these riverine NPS units.*
4. Assess changes in natural biological communities, particularly those of high diagnostic potential (e.g. diatoms) or of special concern (e.g. mussels, amphibians). ***Justification**: A primary concern about water quality change is its impact on biological communities, especially for threatened/endangered groups such as native mussels and groups of high public concern (native fish, amphibians). It is also likely that direct monitoring of water quality parameters may miss emerging environmental changes that bio-monitoring could detect.*
5. Assess changes in population levels or ranges of aquatic nuisance species, especially introduced exotics such as carp and zebra mussels. ***Justification**: The primary threat to native mussel communities in the SACN and MISS is from zebra mussels. Exotic carp species appear to be expanding their range into the upper Mississippi system, with unknown consequences to native fish communities.*
6. Assess changes in critical or emerging environmental contaminants (mercury, PDBEs, endocrine disrupters) at higher levels in the food chain. ***Justification**: The primary impacts of trace environmental pollutants such as mercury or PCBs occur at the upper levels of the food chain. Direct measurement of contaminant levels in water is notoriously difficult and ineffective in predicting biological consequences.*

Basic Approach:

Refine monitoring questions: Input on environmental issues facing the SACN and MISS will be sought from NPS resource managers for the SACN and MISS along with other agencies involved in river management. This information will be used to refine monitoring questions as outlined above, including parameters and methods that would be most useful in answering these questions.

Existing datasets and ongoing monitoring: Water quality of the St. Croix and upper Mississippi rivers has been monitored at key main-stem locations on a continuous basis since the 1970s and from selected tributaries for short term (1-2 year) studies over that same period. This monitoring, primarily by the Minnesota Pollution Control Agency (MPCA), Minnesota Community Education and Services (MCES), and US Geological Service, (USGS) has been recently collated and summarized by the NPS regional aquatic specialist (for SACN) and MCES staff (for MISS). Similarly, daily river flows have been measured at St. Croix Falls (SACN) and Prescott (MISS) for over a century. Efforts to monitor (and restore) native mussel populations as well as the expansion of exotic ANS by multiple state/federal/university partnerships are also ongoing. One of the first tasks for this project is to evaluate these existing and current monitoring efforts to determine: (1) routines for transfer of key WQ parameters into the NPS-GLKN database, (2) evaluation of sampling and analytical methods for consistency with GLKN protocols, and (3) determination of gaps (geographical or desired parameters) in ongoing monitoring efforts.

Establish monitoring framework: Designing a network of sampling locations that captures geographic variability in WQ parameters and complements ongoing monitoring efforts will be a key subtask in protocol development. Sampling locations will need to consider existing monitoring sites, flow measurements, tributary watershed characteristics, and motoring sites for other vital signs (e.g. land use/landscape change).

Develop sampling and analytical protocols: A detailed methodology for sampling and analytical measurement will be developed in a manner consistent with WQ protocols for stream systems as well as those for other NPS networks (e.g. core water quality suite). The protocols will take into account approaches used for ongoing monitoring at SACN and MISS as well as the methodologies used for important historical datasets. There are well-established methods for both physical/chemical measurements and biomonitoring of aquatic systems, and these will be vetted in the selection of procedures that are scientifically robust, logistically feasible, and cost effective.

Principal Investigators and NPS Lead:

Protocol development will be done through a cooperative agreement with the St. Croix Watershed Research Station, Science Museum of Minnesota (16910 152nd St. N., Marine on St. Croix, MN 55047, 651-433-5953). Principal Investigators will be Daniel Engstrom, SCWRS Director and Laura Triplett, Doctoral Candidate in Geology and Geophysics, University of Minnesota (Ms. Triplett's dissertation research deals with historical water quality trends in the SACN). NPS Lead: Joan Elias, GLKN (715-682-0631 x24).

Development Schedule and Expected Interim Products:

Protocol development will not require field research and will consist primarily of evaluating historical datasets and ongoing monitoring efforts and writing a protocol that meets NPS standards and incorporates existing WQ protocols. Interim product development will follow the subtasks set forth in the *Basic Approach* section (above) in the form of summary progress reports (target submission dates noted): (1) Monitoring questions: (8/04); (2) Existing datasets and ongoing monitoring (2/05); (1&2) Status Report (3/05) (3) Monitoring framework (4/1/05); (3) Draft protocol (9/05); final protocol (12/05).

Budget:

Line Item	Cost
Wages and benefits	
PI	$ –
Graduate Assistant	$28,000
Travel	
Collaborative Meetings	$2,000
Subtotal	$30,000
Overhead (@ 17.5%)	$5,250
Total Subproject	**$35,250**

Protocol Development Work Plan

Long-term monitoring of amphibians in the Great Lakes Network

Parks Where Protocol Will Be Implemented: All nine parks in the Great Lakes Network – APIS, GRPO, INDU, ISRO, MISS, PIRO, SACN, SLBE, VOYA.

Justification/issues being addressed: Amphibians have been ranked among the top ten vital signs for all nine park units in the Great Lakes Network. The reasons for this high ranking include the following:

- Amphibian population declines are among the most prominent global issues in conservation biology.
- Amphibians generally are sensitive to changes in environmental factors, including temperature, moisture, hydrology, land cover, nutrients, toxicants, and exotic species, among others, and are highly-linked in food webs.
- Many species of amphibians live in both terrestrial and aquatic habitats and thus their fitness is a function of environmental conditions across habitats.
- Various life stages of amphibians typically allow for rigorous sampling designs for monitoring. This same quality is invaluable for conducting manipulative experiments when further studies are necessary to establish cause and effect.

Specific Monitoring Questions and Objectives to be Addressed by this Protocol: Our overall objective is to develop a protocol for monitoring amphibians that ultimately will provide lines of evidence on the health of ecosystems in units of the Great Lakes Network. We will develop network-wide protocols for monitoring amphibians with appropriate variations for species and habitats. We developed the following five questions as the initial set to be addressed by this protocol. We will refine and add to these questions as one of the first steps in this project. Further, we will consider broadening the protocol to include turtles and other reptiles in future work under this or separate agreement.

Questions

1. How does presence and percent area occupied vary over time and space for target species?
2. Are presence and percent area occupied associated statistically with environmental variables such as climate, land cover, water quality, and water quantity?
3. What are the frequencies of deformities among metamorphosed amphibians over space and time?
4. Are frequencies of deformities associated with climate, land cover, water quality, and water quantity?

Objectives

1. Conduct extensive visual and call surveys of amphibian breeding sites with pre-defined areas of inference.
2. Co-locate sampling sites with those of other monitoring protocols. Measure multiple variables in the association with measurements of amphibians. Conduct statistical tests for association and use other statistical techniques to analyze relationships among measured variables.
3. Measure frequencies of deformities among metamorphs of targeted species of amphibians.

4. Measure frequencies and types of deformities in metamorphosed amphibians at co-located monitoring sites. Conduct statistical tests for association and use other statistical techniques to analyze relationships among measured variables.

Basic Approach: This protocol will be one of five developed initially for the Great Lakes Network as part of a collaborative effort to design a cost effective, scientifically rigorous sampling framework. We will develop a draft protocol following further refinements of the above monitoring questions in collaboration with staff from the Inventory and Monitoring Program and individual units of the Great Lakes Network. We ultimately will describe methods and sampling designs based upon the specific scientific questions, the experiences, approaches, and results of our sampling for herps in three units of the Great Lakes Network during 2002 – 2004 (funded under the GLKN Inventory program), the protocols of ARMI nationally, results of similar efforts described in the scientific literature, and discussions with experts.

Principal Investigators and NPS Lead: Dr. Walt Sadinski, USGS, Upper Midwest Environmental Sciences Center, La Crosse, WI, will be the principal investigator. The NPS lead on this project will be Bill Route, Ecologist/Coordinator, Great Lakes Network.

Development Schedule and Expected Products: July 1, 2004, is the starting date for this project and we expect it to submit final products on or before December 1, 2005. However, there is allowance to modify and extend this agreement to accommodate unexpected problems. Final products will include a peer-reviewed technical report detailing the monitoring protocols as outlined by Oakley et al. (2004) and an oral presentation at a professional conference. We also expect to produce a relevant portion of a manuscript for publication in a scientific journal based upon the combined protocols produced for the Great Lakes Network.

July 2004 – Conference call with NPS staff, the PI for protocol development, and developers of the other sampling protocols for the Great Lakes Network. Begin refining monitoring questions in consultation with NPS lead.

July 2004 – Obtain and review databases on species of amphibians that live in the units of the Great Lakes Network and review established protocols published in the scientific literature and known to be in use by other investigators.

August 2004 – Meet with NPS staff, the PI for protocol development, and developers of other sampling protocols for the Great Lakes Network. The result of this meeting will be refined monitoring questions.

September 2004 – Submittal of a conspectus of progress to date to NPS for incorporation into the Great Lakes Network's Phase 2 Report.

September 2004 – January 2005 – Analyze and evaluate protocols from inventories conducted during 2002 – 2004 under separate agreement.

January 2005 – Progress meeting with NPS staff, the PI for protocol development, and developers of other sampling protocols for the Great Lakes Network. The result of this meeting will be one or more potential sampling frameworks for monitoring resources in the nine parks.

January – April 2005 – Continued development of draft protocol.

March 2005 – Submit status report and abstract the report in the NPS web-based Investigator's Annual Report (IAR).

May – July 2005 – Production of draft protocol.

July 2005 – Submittal of draft protocol to USGS for internal and external peer and administrative review.

September 2005 – Submittal of draft protocol to NPS for further peer review

September 2005 – Submittal of draft portion of manuscript to USGS for internal and external peer and administrative review.

December 1, 2005 - Submittal of final protocol to the project Principal Investigator and NPS.

Budget for amphibian protocol development:

Line Item	Amount
Wages and Benefits	
PI (4.5 pp)	$17,400.00
GS9/1 (1 pp)	$2,100.00
Subtotal Wages and Benefits	**$19,500.00**
Travel	
Collaborative Meetings	$1,500.00
Project-specific	$500.00
Subtotal Travel	**$2,000.00**
Equipment	$0.00
Supplies	**$500.00**
Total Direct Costs	**$22,000.00**
TDC + Common Services Science (4% * TDC)	**$22,880.00**
TDC + CSS + Bureau Assessment [11% (TDC + CSS)]	**$25,396.80**
Total Costs to NPS	**$25,396.80**
TDC + CSS + Indirect Costs (31.64% * TDC)	$28,960.80
TDC + CSS + IC + Bureau Assessment [(11% * $28,960.80) + $28,960.80]	$32,146.49
Cost Share ($32,146.49 – $25,396.80)	$6,749.69
Total Project Costs (difference from NPS cost = USGS contribution)	$32,146.49